

Comment on Faizal et al EPJC 76:30

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Abstract

In a recent paper in EPJC January 2016, Faizal, Khalil and Das have proposed time crystals with duration several orders of magnitude greater than Planck scale. We comment on this paper and shed further light on this aspect.

Recently Faizal et al., in this journal [1] described time crystals which are several orders of magnitude greater than the Planck scale. The discreteness and hence noncommutativity of spacetime has been considered in the literature from the 1940s. In the earlier attempts the scale at which this discreteness takes place has been the Planck scale. Several authors like Snyder, Schild, Kadyshevskii, Ginsburg, Caldirola and others have considered this discreteness, as also in very recent Quantum Gravity approaches [2, 3]. However the author considered discreteness at the Compton Scale to develop his successful cosmology of 1997 [4, 5, 6]. This predicted in advance a slowly accelerating universe driven by what we today call dark energy, when the standard big bang model said exactly the opposite. It was of course argued at length by Wigner and Salecker [7] in the late fifties that there cannot be a physical time within the Compton Scale. Further the author showed more than 12 years ago in several papers in Foundation of Physics and Chaos, Solitons and Fractals, how the coherent Compton Scale arises from the Planck Scale through a coherence approach including the Landau-Ginsburg phase transition [8, 9]. So, even though as in the Prigogine cosmology a Big Bang event would lead to the Planck scale or Wheeler's Quantum Foam [10], this would lead to a several order of magnitude higher scale through phase transition. In fact just prior to the phase transition we would have

$$-\frac{\hbar^2}{2m}\nabla^2\psi + \beta|\psi|^2\psi = -\alpha\psi \quad (1)$$

In (1) ψ denotes the wave function of the particle at a point which is in the impenetrable Planck length. Its derivation is explained in [3, 9]– but basically it stems from a simple two or more state model of probability amplitudes first worked out by Feynman.

Equation (1) leads to the Landau-Ginsberg phase transition with coherence length

$$\xi = \left(\frac{\gamma}{\alpha} \right)^{\frac{1}{2}} \quad (2)$$

ξ which is in the left side is the coherence length, γ is $\hbar^2/2m$ is in the Landau theory and $\alpha = mc^2$ is the energy.

This is the Compton scale (Cf.ref.[3]) in our case.

More recently this was also shown by Beck and Murray [11] and even more recently it was argued in The European Physical Journal C by Faizal, Khalil and Das [1].

On the contrary sticking to the Planck Scale without such a phase transition could prove disastrous as recently articulated by Harry Cliff of Cambridge University and the LHC Collaboration - it would lead to the end of physics, particularly because of the cosmological constant being, in this case 10^{120} times its observed value [12, 13].

Acknowledgment

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References

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APPENDIX (OPTIONAL)

1. Let us see this in a little greater detail: Starting with a simple superposition of states model, first invoked by Feynman, we have:

$$\psi_i(t - \Delta t) - \psi_i(t + \Delta t) = \sum_j \left[\delta_{ij} - \frac{i}{\hbar} H_{ij}(t) \right] \psi_j(t) \quad (1)$$

In the limit this can be shown to lead to

$$i\hbar \frac{\partial \psi}{\partial t} = \frac{-\hbar^2}{2m'} \frac{\partial^2 \psi}{\partial x^2} + \int \psi^*(x') \psi(x) \psi(x') U(x') dx', \quad (2)$$

In the above $U(x') = 1$ for x' in a δ interval, a small interval around this point and $= 0$ outside $[1,2]$.

In the Landau-Ginsburg case there is a coherence length which is given by

$$\xi = \left(\frac{\gamma}{\alpha} \right)^{\frac{1}{2}} = \frac{\hbar \nu_F}{\Delta} \quad (3)$$

which now appears as the Compton wavelength. From the slightly different analysis of Planck oscillators we come to the same conclusion [3]. So the picture that emerges is, starting with Wheeler's Quantum Foam,[4], presumably immediately after the Big Bang, we are lead to the Compton scale.

2. Let us come to the problem of the cosmological constant. This was noticed some decades ago by Zeldovich and others and become well known as the cosmological constant problem. The problem is that if we consider the Zero Point Energy at the Planck scale, the cosmological constant which is the vacuum energy density becomes enormous. Roughly give the Planck scale this would be of the order

$$\frac{mc^2}{l^3} \sim 10^{115} \quad (4)$$

This enormous value is some 10^{120} times the observed value. But now let us consider this at the Compton scale. Then as can be seen from (4) the cosmological constant would be reduced by a factor of 10^{80} aligning it with observation.

4. The above argument in fact provides us with a unified description of electromagnetism and gravitation. It is well known in spite of a century's effort, starting from Hermann Weyl, right up to string theory there has been no satisfactory "unification" of electromagnetism and gravitation. In fact Pauli observed that we should not try to unify what nature had meant to be separate. But let us consider the following argument: First let us invoke the work of Cercignani [5] in a pre dark energy era. He used Quantum oscillations invoking the usual Zero Point Field. He showed, using the fact that mass and energy were equivalent, that chaotic oscillations are present whenever mass is of the order

$$G[\hbar\omega c^{-2}]^2[\omega^{-1}c]^{-1} = G\hbar^2\omega^3c^{-5} \quad (5)$$

where G is the constant of gravitational attraction and we have used the wavelength for the distance.

If this were to be less than the electromagnetic energy $\hbar\omega$ then we must have

$$(G\hbar)^{-1/2} \cdot c^{5/2} \quad (6)$$

This is what may be called a gravitational cut off for the frequency in the Zero Point Energy. In other words above this cut off frequency for the Zero

Point Energy we have gravitation but below it we come to the realm of electromagnetism. This maximum frequency oscillation is given by

$$G\hbar\omega_{max}^2 = c^5 \quad (7)$$

Interestingly (7) shows that at the Planck scale the electromagnetic and gravitational strengths are of the same order. However after the phase transition when we come to the Compton scale, we have the usual electromagnetic field. So the phase transition leads from gravitation to electromagnetism, providing a unified description.

References for the Appendix

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